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Influence of Temperature on Life Table Parameters of the Predaceous Mite *Euseius finlandicus* (Oudemans) (Acari: Phytoseiidae)

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Abstract: This study determined the differences in development time, survival, and fecundity of *Euseius finlandicus* (Oudemans) (Acari: Phytoseiidae) when feeding on *Tetranychus urticae* (Koch) (Acari: Tetranychidae) together with birch pollen at 16, 20, 25, and 30 ± 1 °C, 65 ± 10% RH, and 16:8 photoperiod under laboratory conditions. Total development times for *E. finlandicus* were 29.48, 18.15, 7.28, and 5.90 days for females and 28.16, 17.54, 7.03, and 5.81 days for males at 16, 20, 25, and 30 ± 1 °C, respectively. Total egg production was highest (30.53 eggs) at 25 °C, whereas daily egg production was highest (1.80 eggs) at 30 °C. Female longevity was 74.39, 58.93, 28.05, and 16.67 days at 16, 20, 25, and 30 ± 1 °C, respectively. The development threshold for eggs and egg to adult stages were 13.78 °C and 13.22 °C for females and 13.72 °C and 13.10 °C for males, respectively. Females and males required 95.24 and 94.34 degree-days, respectively, to became adult. *Euseius finlandicus* had the highest intrinsic rate of increase (r_m), 0.220 females/female/day at 30 °C, followed by 0.165 females/female/day at 25 °C, 0.064 females/female/day at 20 °C, and 0.033 females/female/day at 16 °C.

Key Words: Birch pollen, development, *Euseius finlandicus*, fecundity, life table, temperature, *Tetranychus urticae*

Avcı Akar *Euseius finlandicus* (Oudemans) (Acari: Phytoseiidae)'un Yaşam Parametreleri Üzerine Sıcaklığın Etkisi

Özet: Bu çalışmada, 16, 20, 25 ve 30 ± 1 °C sıcaklık, % 65 ± 10 nem değerlerine ve 16:8 saat ışıklanma süresine ayarlı laboratuvar koşullarında, *Tetranychus urticae* (Koch) (Acari: Tetranychidae) ile birlikte huş ağacı polenleri üzerinde beslenen avcı akar *Euseius finlandicus* (Oudemans) (Acari: Phytoseiidae)'un biyolojisi ve üreme gücü araştırılmıştır. Avcı akar *E. finlandicus*'un 16, 20, 25 ve 30 ± 1 °C sıcaklıklardaki gelişme süresi sırasıyla dişi bireyler için 29.48, 18.15, 7.28 ve 5.90 gün, erkek bireyler için ise 28.16, 17.54, 7.03 ve 5.81 gün olarak belirlenmiştir. *Euseius finlandicus*'un toplam yumurta üretimi 25 °C de en yüksek (30.53 yumurta) iken, günlük yumurta üretimi 30 °C de en yüksek (1.80 yumurta) olarak saptanmıştır. Dişi bireylerin ömrü 16, 20, 25 ve 30 ± 1 °C sıcaklıklarda sırası ile 74.39, 58.93, 28.05 ve 16.67 gün olarak belirlenmiştir. Avcı akar *E. finlandicus*'un gelişme eşiği dişi bireylerin yumurta dönemleri için 13.78 C^{o}, ergin öncesi dönemleri için ise 13.22 °C, erkek bireyler için ise bu değerler sırasıyla 13.72 °C ve 13.10 °C dir. Bu değerlerden yola çıkılarak *E. finlandicus*'un gelişebilmesi için ihtiyaç duyduğu etkili sıcaklıklar toplamının, dişiler için 95.24 gün - derece, erkek bireyler için ise 94.34 gün - derece olduğu hesaplanmıştır. *Euseius finlandicus*'un kalıtsal üreme yeteneği (r_m), en yüksek 0.220 dişi/dişi/gün ile 30 °C sıcaklıkta saptanmış, bu sıcaklığı 0.165 dişi/dişi/gün ile 25 °C ve 0.064 dişi/dişi/gün ile 20 °C izlemiştir. En düşük r_m değeri ise 0.033 dişi/dişi/gün ile 16 °C sıcaklıkta elde edilmiştir.

Anahtar Sözcükler: Huş ağacı poleni, gelişme, *Euseius finlandicus*, doğurganlık, yaşam tablosu, sıcaklık, *Tetranychus urticae*

Introduction

Tetranychid mites (Acarina: Tetranychidae) are very harmful phytophagous mites that are widespread on many crops and ornamental plants. In particular, *Tetranychus urticae* Koch (Acari: Tetranychidae), important phytophagous mites, feeds on more than 150 species of host plants, mainly vegetables and deciduous fruit trees (van de Vrie et al., 1972; Jeppson et al., 1975; Sabelis,

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1981; Krips et al., 1998; Kasap, 2004; Kasap et al., 2004, 2007). Most of the recent studies on the biological control of tetranychids have focused on the family Phytoseiidae because of its ability to maintain prey populations at low densities (McMurtry and Croft, 1997). Predaceous mites are natural enemies of phytophagous mites and other crop pests and play an important role in their natural control (Helle and Sabelis, 1985; McMurtry and Croft, 1997; Schausberger, 1997; Croft and Luh, 2004). *Euseius finlandicus* (Oudemans) (Acari: Phytoseiidae), one of the few *Euseius* species found in temperate climates, is a widespread phytoseiid species on apple, peach, grape, cherry, and hazelnut (Van de Vrie, 1975; Schausberger, 1992; Duso and Vettorazzo, 1999; Broufas and Koveos, 2000; Abdallah et al., 2001; Broufas and Koveos, 2001; Ozman and Cobanoglu, 2001). *Euseius finlandicus* feeds on tetranychid, eriophyid, and tarsonemid mites, eggs and preadult stages of some insects, pollen, fungal spores, honeydew, and plant liquids, and is known to play an important role in the natural control of spider mites and eriophyid mites, especially *Panonychus ulmi* (Koch) and *Aculus schlechtendali* (Nalepa) on apple (Çobanoğlu, 1992; Kostiainen and Hoy, 1994; Schausberger, 1997, 1998; Broufas and Koveos, 2000; Abdallah et al., 2001; Broufas and Koveos, 2001). *Euseius* species are characterized as specialized pollen feeders (type IV) and generalist predators (McMurtry and Croft, 1997; Croft et al., 2004), and *E. finlandicus* can feed and develop on a number of different plant pollens (Schausberger, 1992; Kostiainen and Hoy, 1994; Broufas and Koveos, 2000; Abdallah et al., 2001). During the period 2002-2006, the surveys of mite fauna in apple and walnut orchards around Van Lake in the Van province of eastern Turkey revealed that *E. finlandicus* was either the only phytoseiid or the most abundant in some orchards (Kasap et al., 2004, 2007). It is also a very common species and an important biological control agent of tetranychids in the other apple-growing districts in Turkey (Düzgüneş and Kılıç, 1983; Şekeroğlu, 1984; Çobanoğlu, 1992; Yıldız, 1998).

Since temperature strongly affects the developmental and reproductive performance of predatory species used as biocontrol agents, understanding the temperature requirements of a predatory species can be of use in estimating its potential reproductive rates and population dynamics. The intrinsic rate of natural increase (r_m) is an important parameter for assessing the reproductive potential of a predator under laboratory conditions, and temperature is a significant determinant of the intrinsic rate of natural increase (Sabelis, 1985; Janssen and Sabelis, 1992; Roy et al., 2003). There are many reports on the effect of temperature and different foods on the development and reproduction of *E. finlandicus* from all over the world (Schausberger, 1992; Kostiainen and Hoy, 1994; Broufas and Koveos, 2000; Broufas and Koveos, 2001; Abdallah et al., 2001). No report, however, was introduced from Turkey. Studies on the life table of predators from different geographical regions are important in biological control studies, and they are necessary for the background of IPM programs (Sabelis, 1985; Pedigo and Zeiss, 1996). Therefore here, the effects of temperature on the development and reproductive performance of *E. finlandicus* fed on *T. urticae* and birch pollen together under laboratory conditions from Turkey are reported.

Materials and Methods

Mite cultures

The initial population of *E. finlandicus* was collected from apple trees (*Malus communis* L.) in Van province of Turkey. The stock culture of predatory mite was maintained on *T. urticae* and birch pollen (*Betula pendula* Roth) settled on bean leaves in a rearing chamber (25 ± 2 °C, 65 ± 10% RH, 16:8 L:D). In previous experiments, birch pollen has been suggested to be important for building up the populations of *E. finlandicus* (McMurtry, 1985). Two bean leaves were placed upside-down on a layer of filter paper on a 2 cm deep distilled water - saturated polystyrene pad inside a 20 × 15 × 5 cm plastic box. Water was added daily to keep the filter paper and polystyrene pad wet and to cover the base of the box to prevent the escape of mites. A surplus of various stages of *T. urticae* was brushed daily onto the leaves using a soft brush and a funnel. Birch pollen (0.5-0.10 mg) was also provided as food in every other day to the predatory mites. Leaves were renewed once a week. The predatory mites were reared for at least 2 consecutive generations before the experiments. The *T. urticae* used as prey were reared on bean plants (*Phaseolus vulgaris* L. cv Barbunia) under the same conditions.

Effects of temperature on development of *E. finlandicus*

Mature, but not senescing, bean leaves were used as experimental areas. For each area, a leaf was placed on a layer of filter paper on distilled water - saturated polystyrene pad in a 100 × 15 mm petri dish. Each leaf was covered with filter paper that had a 40 mm diameter opening in the center as a barrier to prevent the escape of prey and predator. A surplus of various stages of *T. urticae* was brushed daily onto the leaf arenas using a soft brush and a funnel. Pollen grains (0.2-0.3 mg/day) were also provided to the predatory mites, and the bean leaves were renewed weekly.

For the experiments approximately 30 adult females from stock culture were transferred to each area for egg laying and removed after 12 h, and eggs were placed 1 per arena for subsequent observations. Males that escaped from the leaf arena or died were replaced by new ones from stock culture. Females that escaped from the leaf arena and happened to drown in the wet filter paper were excluded from data analysis. The developmental stages of immature *E. finlandicus* were observed at 12 h intervals until they became adult. The presence of an exuvium was used as the criterion for successful molting to the next developmental stage. Egg incubation period, duration of protonymphal and deutonymphal stages, adult preoviposition, oviposition and postoviposition periods, and sex ratios were recorded for each temperature treatment.

Effects of temperature on the life table parameters of *E. finlandicus*

Newly mated *E. finlandicus* females were confined 1 per leaf arena and were fed as described above. Eggs were collected daily and reared up to adult stage; sex ratios were then determined visually. Observations were conducted on a daily basis. Life tables were constructed using the data collected on developmental and adult characteristics at 16, 20, 25, and 30 ± 1 °C, 65 ± 10% RH, and a 16:8 (L:D) photoperiod.

Statistical analysis

Data were analyzed using 1-way analysis of variance (ANOVA) and Student-Newman-Keuls Sequential Tests. The thermal thresholds of the egg stage and development time (egg to adult) were computed using a linear equation, with growth-rate data (day^{-1}) as the dependent variable and temperature as the independent variable. The lower developmental threshold temperature (the minimum temperature for development) was determined as the x-intercept of the linear equation and the degree-day (DD) requirements were determined as the inverse of the slope of the linear equation (DD = 1 / b). The regression equation: v = a + bt (where a is intercept, and b is slope) was used (Sharov, 1998).

Life tables were constructed according to Birch (1948) using data on age-specific survival rates (l_x) and numbers of female offspring per female (m_x) for each age interval (x) per day to calculate net reproductive rates (R_0 = females/female/generation), intrinsic rates of natural increase (r_m = females/female/day), mean generation times ($T_0 = \ln(R_0 / r)$, in days) and doubling time ($DT = \ln(2) / r_m$, in days), the time required for doubling the initial population, at 4 different temperatures. Differences in r_m values were tested for significance by estimating the variance using the jackknife method, which facilitated the calculation of standard errors of the r_m estimates. The jackknife pseudo value r_j was calculated for n samples using the following equation: $r_j = nxr_{a11} - (n-1)\ xr_i$ (Sokal and Rolf, 1981; Krebs, 1998). The mean values of (n – 1) jackknife pseudo values for the mean growth rate in each treatment were subjected to ANOVA and Student-Newman-Keuls Sequential Tests. All statistical analyses were conducted using SAS statistical software (SAS institute, 1998).

Results

Effects of temperature on development of *E. finlandicus*

The development times of *E. finlandicus* are given in Table 1. Development time decreased as temperature increased from 16 °C to 30 °C for both females ($F_{3.82}$ = 1122.80; P < 0.0001) and males ($F_{3.48}$ = 716.00; P < 0.0001). While the overall development time was shorter for males than females, this difference was not statistically significant (Table 1, t test = 1.48; df = 27; P > 0.005). There was not any mortality of immature stages observed at 16, 20 and 25 °C compared to 5% mortality at 30 °C.

Linear regression analysis showed that development rates for the egg stage ($r_{[Te]}$) of *E. finlandicus* increased linearly with an increase in temperature from 16 °C to 30 °C. The theoretical lower developmental threshold of the egg stage was estimated to be 13.78 °C for females and 13.72 °C for males, and hatching required 28.01 degree-days for females and 27.86 degree-days for males. The overall developmental rate ($r_{[Tt]}$) increased linearly with increases in temperature (Figure 1). The theoretical lower development threshold was estimated to be 13.22 °C for females and 13.10 °C for males. Based on these developmental thresholds, complete development from egg to adult required 95.24 degree-days for females and 94.34 degree-days for males.

Table 1. Duration (days) of immature stages of *Euseius finlandicus* at 4 different temperatures (Mean ± SE). [1, 2]

Female	16 ± 1 °C	20 ± 1 °C	25 ± 1 °C	30 ± 1 °C	F ratio
n	18	20	28	20	
Egg	8.92 ± 1.14 a	6.60 ± 0.91 b	2.24 ± 0.55 c	1.76 ± 0.35 c	307.59
Larvae	1.93 ± 0.54 a	1.52 ± 0.46 b	0.92 ± 0.18 c	0.75 ± 0.16 c	47.15
Protonymph	8.67 ± 1.13 a	4.95 ± 0.87 b	2.30 ± 0.54 c	1.86 ± 0.48 c	329.51
Deutonymph	9.96 ± 1.66 a	5.08 ± 0.95 b	1.82 ± 0.71 c	1.53 ± 0.42 c	308.44
Total	29.48 ± 2.33 a	18.15 ± 1.72 b	7.28 ± 0.84 c	5.90 ± 0.66 d	1122.80
Male					
n	11	13	18	11	
Egg	8.52 ± 1.51 a	6.58 ± 0.65 b	2.21 ± 0.64 c	1.74 ± 0.34 c	238.40
Larvae	1.56 ± 0.47 a	1.24 ± 0.39 b	0.86 ± 0.21 c	0.71 ± 0.18 d	16.45
Protonymph	7.92 ± 1.90 a	4.61 ± 0.64 b	2.01 ± 0.47 c	1.76 ± 0.36 c	102.87
Deutonymph	10.16 ± 1.52 a	5.11 ± 0.85 b	1.92 ± 0.55 c	1.61 ± 0.45 c	232.83
Total	28.16 ± 2.28 a	17.54 ± 1.38 b	7.03 ± 0.80 c	5.81 ± 0.48 d	716.00

Total: Total development time (egg to adult); n: Numbers of replicates included in analysis
[1] Means in a row followed by the same letter are not statistically different (Student-Newman-Keuls Test P > 0.05)
[2] For both sexes, within column, means are significantly different (t test; P > 0.05)

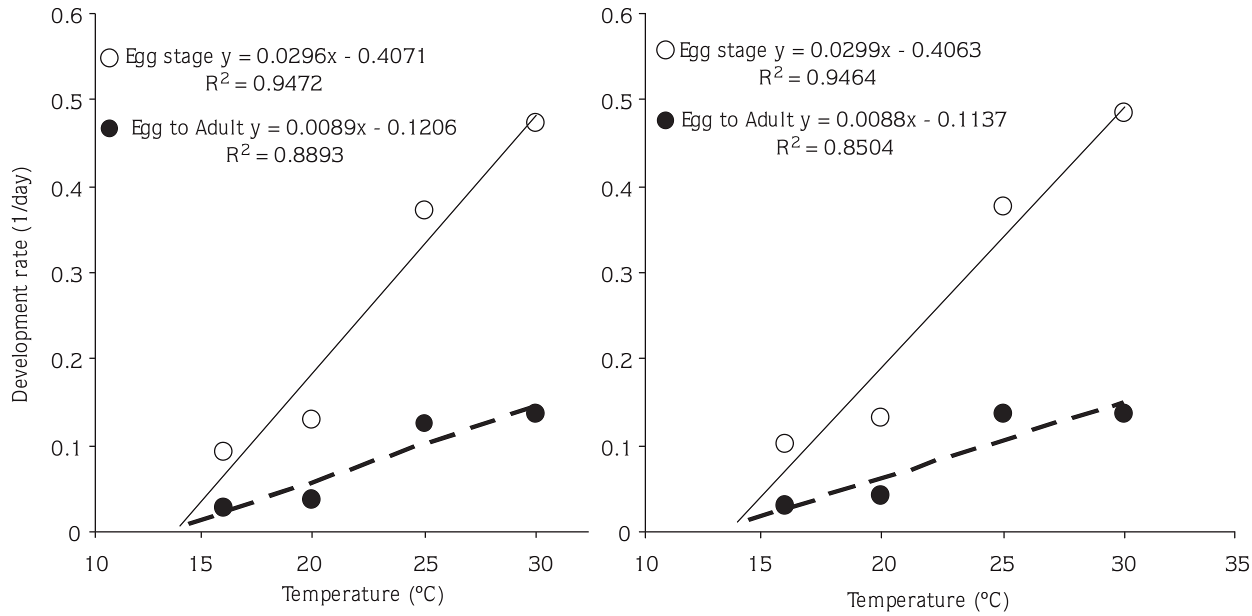

Figure 1. Developmental rate of eggs ($r_{[Te]}$) and total developmental rate (eggs to adult) ($r_{[Tt]}$) of *Euseius finlandicus* (females and males). Lines represent linear regressions of developmental rates on temperature within the range of 16 – 30 °C.

The duration of preoviposition, oviposition, and postoviposition periods in *E. finlandicus* are given in Table 2. The preoviposition period were longer at 16 °C and 20 °C than those at 25 °C and 30 °C, and these differences were statistically significant ($F_{3.62}$ = 117.91; P < 0.0001). The oviposition period were the longest at 16 °C and decreased as the temperature increased ($F_{3.62}$ = 58.30; P < 0.0001). The postoviposition period were longer at 16 °C and 20 °C than those at 25 °C and 30 °C, with the shortest period at 30 °C ($F_{3.62}$ = 30.87; P < 0.0001).

Table 2. Female longevity, fecundity, and sex ratio of *Euseius finlandicus* at 4 different temperatures (Mean ± SE).[1]

	16 ± 1 °C	20 ± 1 °C	25 ± 1 °C	30 ± 1 °C	F ratio
n	15	15	19	17	
Preoviposition	13.53 ± 3.95 a	12.27 ± 2.22 a	3.32 ± 0.89 b	1.91 ± 0.57 b	117.91
Oviposition	50.49 ± 13.78 a	37.27 ± 10.51b	21.11 ± 3.89 c	13.36 ± 3.84 d	58.30
Postoviposition	10.36 ± 4.55 a	9.40 ± 4.58 a	3.63 ± 1.07 b	1.41 ± 0.94 c	30.87
Female longevity	74.39 ± 13.91 a	58.93 ± 12.60 b	28.05 ± 4.18 c	16.67 ± 4.36 d	128.88
Total fecundity	12.33 ± 4.22 c	24.07 ± 6.93 b	30.53 ± 5.91 a	27.65 ± 7.18 ab	26.74
Daily fecundity	0.23 ± 0.21 d	0.60 ± 0.34 c	1.34 ± 0.37 b	1.80 ± 0.44 a	180.41
Sex ratio (♀/(♀+♂))	0.59	0.63	0.59	0.60	

[1] Means in a row followed by the same letter are not statistically different (Student-Newman-Keuls Test P > 0.05), n: Numbers of replicates included in analysis

Female longevity was shortest at 30 °C (16.67 days), followed by 25 °C (28.05 days), 20 °C (58.93 days) and 16 °C (74.39 days) ($F_{3.62}$ = 128.88; P < 0.0001) (Table 3 and Figure 2).

Mean total and daily fecundity of *E. finlandicus* at 4 different temperatures are also given in Table 2. Mean total fecundity values were 12.33, 24.07, 30.53, and 27.65 eggs at 16, 20, 25, and 30 °C, respectively. Mean total fecundity at 25 °C was statistically higher than mean total fecundity at 16 °C and 20 °C; however, there were no statistical differences between mean total fecundity values at 20 °C and 30 °C ($F_{3.62}$ = 26.74; P > 0.0001). Daily fecundity of *E. finlandicus* was lowest at 16 °C and highest at 30 °C ($F_{3.172}$ = 180.41; P < 0.0001). Daily egg production peaked on the day 43 (0.35 eggs/female/day) at 16 °C, the day 37 (0.67 eggs/female/day) at 20 °C, the day 12 (1.18 eggs/female/day) at 25 °C and the day 10 (1.48 eggs/female/day) at 30 °C (Figure 2). The sex ratio (♀ / (♀ + ♂)%) of *E. finlandicus* was biased towards females and varied with temperature from 59% to 63% (Table 2).

Effects of temperature on the life table parameters of *E. finlandicus*

Life table data for *E. finlandicus* at 4 different temperatures are given in Table 3. The intrinsic rate of natural increase (r_m) of *E. finlandicus* increased with increases in temperature from 0.033 females/female/day at 16 °C to 0.064 females/female/day at 20 °C, 0.165 females/female/day at 25 °C and 0.220 female/female/day at 30 °C. Differences in the intrinsic rates of natural increase in different temperatures were statistically significant ($F_{3.62}$ = 297362.40; P < 0.0001). Population doubling times (DT) was 20.87, 10.85, 4.20, and 3.15 days at 16, 20, 25, and 30 °C, respectively (Table 3). The longest mean generation time (T_o) was at 16 °C (59.84 days), and the shortest mean generation time was at 30 °C (12.75 days). The net reproductive rate (R_o) increased from 7.28 female/female at 16 °C to 15.16 female/female at 20 °C and 18.01 female/female at 25 °C, but decreased to 16.59 female/female at 30 °C (Table 3).

Table 3. Net reproductive rate (R_0), intrinsic rate of increase (r_m), mean generation time (T_0), and doubling time (DT) of *Euseius finlandicus* at 4 different temperatures.[1]

	Net reproductive rate (R_0) (females/female)	Intrinsic rate of increase (r_m) (females/female/day)	Mean Generation time (T_0) (days)	Doubling time (DT) (days)
16 °C	7.28	0.033 ± 0.00012 d	59.84	20.87
20 °C	15.16	0.064 ± 0.00011 c	42.58	10.85
25 °C	18.01	0.165 ± 0.00017 b	17.52	4.20
30 °C	16.59	0.220 ± 0.00027 a	12.75	3.15
F ratio		297362.40[1]		

[1] r_m values followed by different letters are significantly different within column (Student-Newman-Keuls Test P > 0.05)

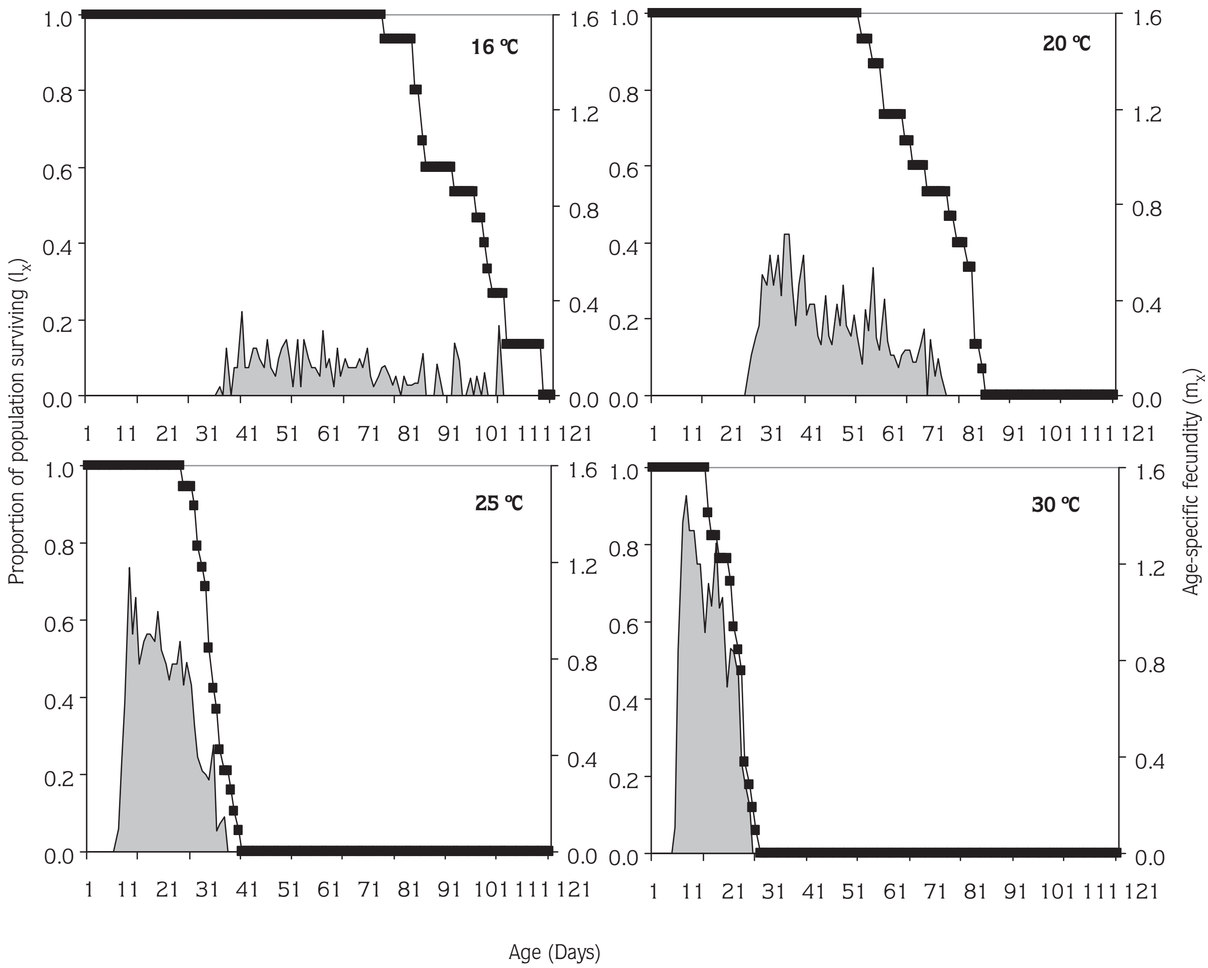

Figure 2. Adult survival (l_x) and age-specific fecundity rate (m_x) of *Euseius finlandicus* at 4 different temperatures.

Discussion

Despite the variability in temperature that occurs under natural conditions, controlled laboratory studies can provide valuable insight into the duration of development and population dynamics of predatory mites such as *E. finlandicus.* The results of this study clearly show the effects of temperature on development time, longevity, and fecundity on *E. finlandicus.* Despite the fact that maximum total fecundity was achieved at 25 °C, *E. finlandicus* performed best at 30 °C, mainly due to its shortest development time (5.90 days), high daily egg production (1.80 eggs), and early peak in reproduction (day 10).

The total developmental time for both sexes of *E. finlandicus* decreased as the temperature increased. These results are in agreement with Bounfour and McMurtry (1987), Rencken and Pringle (1998), Broufas and Koveos (2001), Kazak et al. (2002), Gotoh et al. (2004), and Kasap and Şekeroğlu (2004). The total development times of *E. finlandicus* in this study were substantially longer than those of a Greek strain of *E. finlandicus* feeding on different plant pollens (Broufas and Koveos, 2000; Broufas and Koveos, 2001), but were similar in part to those of a U.K. strain of *E. finlandicus* feeding on *T. urticae* at 25 °C (Abdallah et al., 2001). The differences in findings regarding total development times may be due to differences in prey quality, local populations, and experimental conditions. The intrinsic rate of natural increase (r_m) is an important parameter, describing the growth potential of a population under prevailing climatic and feeding conditions, as a reflection of the overall effects of temperature and food on the population's development, reproduction, and survival characteristics (Sabelis, 1985;

Janssen and Sabelis, 1992; Krips et al., 1998; Roy et al., 2003). In this study, the r_m value of *E. finlandicus* feeding on *T. urticae* and birch pollen increased from 0.033 females/female/day to 0.220 females/female/day as the temperature increased from 16 °C to 30 °C. Similarly, Kazak et al. (2002) found the r_m value of *Neoseiulus umbraticus* (Chant) feeding on *Tetranychus cinnabarinus* (Boisduval) increased from 0.123 females/female/day at 20 °C to 0.180 females/female/day at 30 °C. Gotoh et al. (2004) reported that the r_m value of *Amblyseius californicus* (McGregor) feeding on *T. urticae* increased from 0.173 females/female/day to 0.340 females/female/day with an increase in temperature. Kasap and Şekeroğlu (2004) demonstrated that the r_m value of *Euseius scutalis* (Athias-Henriot) feeding on *Panonychus citri* (McGregor) increased from 0.166 females/female/day to 0.234 females/female/day to 0.295 females/female/day at 20 °C, 25 °C, and 30 °C, respectively. Broufas and Koveos (2001) reported the r_m value of *E. finlandicus* feeding on *Typha* sp. pollen increased from 0.0926 females/female/day at 15 °C to 0.293 females/female/day at 30 °C, but decreased to 0.267 females/female/day at 32 °C.

Several studies have reported changes in r_m values of predatory mites with changes in feeding regimens. McMurtry and Croft (1997) reported that the r_m value of generalist predatory mites increased from under 0.1 females/female/day to 0.25 females/ female/day when fed on spider mites or pollen. Abdallah et al. (2001) found the r_m value of *E. finlandicus* increased from 0.110 female/female/day on spider mites to 0.153 female/female/day on eriophyid mites and 0.168 female/female/day on pollen. Broufas and Koveos (2000) found the r_m value of *E. finlandicus* varied between 0.082 - 0.150 female/female/day when fed on different plant pollens.

With respect to the relevance of the current study to Van province of Turkey, mean daily summer temperatures rarely exceed 30 °C, an optimum temperature for the development and fecundity of *E. finlandicus,* which is one of the most common polyphagous predatory mites found in apple and walnut orchards in Van (Kasap et al., 2004, 2007). It is possible that at times when the temperature does exceed 30 °C, the mites could avoid the adverse effects of the high temperatures by relocating themselves on shaded sites at lower temperatures where their population could increase. Due to its ability to maintain spider mites at low population densities, augmentation of *E. finlandicus* populations may improve the control of spider mites in apple and walnut orchards.

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